

UNIVERSITY COLLEGE LONDON

University of London

EXAMINATION FOR INTERNAL STUDENTS

For The Following Qualifications:–

B.Eng. M.Eng.

Chemical Eng E879: Biochemical Reaction Engineering

COURSE CODE : **CENGE879**

UNIT VALUE : **0.50**

DATE : **07-MAY-04**

TIME : **10.00**

TIME ALLOWED : **3 Hours**

Answer FOUR QUESTIONS. Only the first four answers given will be marked.
ALL questions carry a total of 25 MARKS each, distributed as shown []

1.

This question concerns biocatalytic reactor kinetics.

- a) Derive an expression (based on a mass balance) to describe the productivity of a continuous stirred tank reactor. [12]
- b) Use the expression derived and graphical techniques, as appropriate, to explain why the continuous stirred tank reactor is rarely used in industrial operation. [8]
- c) Under what circumstances might the continuous stirred tank reactor be used? [5]

2.

This question concerns the use of immobilised enzymes within porous particles as biocatalysts for the synthesis of fine chemicals.

- a) What is the rationale for biocatalyst immobilisation? What disadvantages result from immobilisation? [5]
- b) Describe in qualitative and quantitative terms what is meant by diffusional limitation in such immobilised biocatalysts. [6]
- c) Describe a simple experimental test to establish whether there is internal diffusional limitation in a given system. [4]
- d) Using expressions for the Effectiveness Factor, the Damkohler Number and the Thiele Modulus, describe how the diffusional limitations described in (b) can be overcome. [10]

3.

This question concerns substrate and product inhibition in industrial biocatalysis.

- a) Describe qualitatively, and using graphs as appropriate, what is meant by substrate and product inhibition. [5]
- b) What techniques (including biological and process related methods) are available to overcome these limitations to biocatalytic processes? [7]
- c) Devise a table listing the key advantages and disadvantages of each technique in (b), taking into account the time to implement the technique and the degree of improvement which can be achieved. [13]

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4.

This question concerns the use of organic solvents in biocatalysis

- a) Under what circumstances are organic solvents added to biocatalytic processes? [5]
- b) What are the main issues involved in the design of such processes? [5]
- c) Outline an experimental plan to evaluate the issues identified in (b). [13]

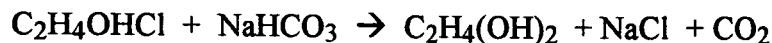
5.

The homogeneous, gas-phase reaction $A \rightarrow 3R$ follows first-order kinetics. For a feed volumetric flowrate of $4 \text{ m}^3 \text{ h}^{-1}$ of pure A, an experimental plug-flow reactor operating at constant temperature and pressure, having a length of 2 m and a diameter of 3 cm, achieves 60% conversion of A.

An industrial PFR, operating at the same temperature and pressure as the experimental reactor, will be used to process $320 \text{ m}^3 \text{ h}^{-1}$ of feed which contains 60% A and 40% inerts. Calculate the number of pipes (of length 2 m and diameter 3 cm) needed, if the conversion of A at the exit of the reactor is 85%. [25]

6.

The reaction between ethylene chlorhydrin and sodium bicarbonate to produce ethylene glycol is elementary with rate constant $k = 5.2 \text{ dm}^3 \text{ mol}^{-1} \text{ h}^{-1}$ at $82 \text{ }^\circ\text{C}$.



We wish to construct a pilot plant to determine the economic feasibility of producing ethylene glycol from two available feeds, a 15 wt % aqueous solution of sodium bicarbonate and a 30 wt % aqueous solution of ethylene chlorhydrin.

- a) What volume of a plug flow reactor (PFR) will produce 20 kg h^{-1} ethylene glycol at 95% conversion of a feed containing equimolar proportions of reactants, produced by intimately mixing appropriate quantities of the two feed streams? [15]
- b) What size of a well mixed flow reactor (CSTR) is needed for the same feed, conversion and production rate as in part (a) above? [10]

Assume all operations at $82 \text{ }^\circ\text{C}$, at which temperature the density of the mixed reacting fluid is 1.02 g cm^{-3} .

Additional data.

Relative Molar Mass of $\text{C}_2\text{H}_4\text{OHCl} = 80.5$

Relative Molar Mass of $\text{NaHCO}_3 = 84$

Relative Molar Mass of $\text{C}_2\text{H}_4(\text{OH})_2 = 62.1$

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